

Historic, Archive Document

Do not assume content reflects current scientific knowledge, policies, or practices.

1389.9
R312
Cop. 2

(DO NOT list in B of A)

A Summary of Current Program 7/1/67

and Preliminary Report of Progress

for 7/1/66 to 6/30/67

HUMAN NUTRITION RESEARCH DIVISION

of the

AGRICULTURAL RESEARCH SERVICE

UNITED STATES DEPARTMENT OF AGRICULTURE

and related work of the

STATE AGRICULTURAL EXPERIMENT STATIONS

This progress report is primarily a tool for use of scientists and administrators in program coordination, development and evaluation; and for use of advisory committees in program review and development of recommendations for future research programs.

The summaries of progress on USDA and cooperative research include some tentative results that have not been tested sufficiently to justify general release. Such findings, when adequately confirmed, will be released promptly through established channels. Because of this, the report is not intended for publication and should not be referred to in literature citations. Copies are distributed only to members of Department staff, advisory committee members and others having a special interest in the development of public agricultural research programs.

This report also includes a list of publications reporting results of USDA and cooperative research issued between July 1, 1966, and June 30, 1967. Current agricultural research findings are also published in the monthly USDA publication, Agricultural Research. This progress report was compiled in the Human Nutrition Research Division, Agricultural Research Service, U. S. Department of Agriculture, Beltsville, Maryland.

UNITED STATES DEPARTMENT OF AGRICULTURE

Washington, D. C.

July 1, 1967

U. S. DEPT. OF AGRICULTURE
NATIONAL AGRICULTURAL LIBRARY

SEP 25 1968

CURRENT SERIAL RECORDS

TABLE OF CONTENTS

	Page
Introduction.	iii
Area No. 1: Functions and Metabolism of Nutrients.	1
Area No. 2: Human Metabolism and Requirements for Nutrients. . .	9
Area No. 3: Nutrient Composition of Foods.	16
Area No. 4: Food Properties Related to Quality and Consumer Use.	25
Line Project Check List	36

INTRODUCTION

The research reported here presents recent progress in understanding the nutritional needs of normal man and the manner by which these needs can best be met by food. The research involves studies of the absorption, transport, and metabolism of individual nutrients in the body as related to age, activity, and environmental conditions. Studies of metabolic processes and nutritional requirements in man are preceded, guided, and expedited by results from intensive studies on laboratory animals and lower forms of life in which more factors can be controlled and physiological responses can be measured during each stage in the life cycle and during successive generations. The research includes the nutritive and other consumer values of foods as measured by chemical or physical means and by biologic response, and the effects of household practices upon the nutritive value and inherent qualities of foods. Knowledge gained from human nutrition research can be used to influence the food habits and improve the nutritional status of man. It also can influence market demand and in turn the orientation of production of agricultural products.

The program is carried on by the Human Nutrition Division of the Agricultural Research Service of the U. S. Department of Agriculture. It is conducted at the Agricultural Research Center near Beltsville, Maryland, and under contract and cooperative agreement with universities, medical schools, hospitals, industry, and private research laboratories. In addition, the Division collaborates with Regional programs of the State Experiment Stations. The Federal scientific effort devoted to this research in Fiscal Year 1967 totalled 40.7 scientific man-years with 34.5 engaged in the program near Beltsville, Maryland, and the equivalent of 6.2 in contract, grant, and cooperative agreements. The program is divided among study of:

	Intramural	Extramural	Total
Functions and metabolism of nutrients	13.2	3.9	17.1
Human metabolism and requirements for nutrients	1.7	1.0	2.7
Nutrient composition of foods	10.0	-	10.0
Other food qualities and consumer use	9.6	1.3	10.9

Basic information on human nutrition is needed for conservation and optimal utilization of human and food resources and for nutritional well-being of the population. The Division has contributed to this goal by providing information on nutritional and food needs and on the qualities of foods which influence their usefulness to consumers. Some of these contributions have been summarized here:

Heredity affects level of blood cholesterol. ARS scientists find that blood cholesterol levels in experimental animals may be high even when the diet throughout life is low in fat and cholesterol. When a diet low in fat and cholesterol was fed to one strain of rats, blood cholesterol was within a range considered normal. When the same diet was fed to a second strain of rats, blood cholesterol values were about twice as high and reached levels sufficiently elevated to be a cause for concern. Regardless of the level of blood cholesterol, liver cholesterol values were normal in both strains.

Some dietary fats may trigger the development of goiter in iodine deficient rats. ARS contract research with a Columbia University scientist suggests that certain fats and oils contain substances that aggravate the development of enlarged thyroids characteristic of goiter - a finding that may be of importance in iodine deficient areas. From weaning until death, rats were fed diets that contained marginal amounts of iodine. The diets varied only in the type of fat used. Fat constituted 20 percent by weight of each diet. In contrast to normal thyroids of 23-31 mg., olive oil produced a high incidence of thyroids weighing more than 100 mg. The incidence of large thyroids was low when the diets contained butter, pork, or beef. Chicken fat, soybean oil, and corn oil were intermediate in their effect on thyroid size. Mild oxidation of the fats did not alter response.

Eating quality of frozen turkeys can be comparable to that of fresh turkeys. Cooking procedures have been developed by ARS scientists to assure optimum eating quality of frozen whole turkeys. This research will help consumers get more satisfaction from use of frozen turkeys. Eating quality was shown to be similar for fresh and frozen-thawed turkeys when cooked for equal periods of time rather than to the same end temperature. The most frequent consumer complaints about turkey are the dry texture and decreased tenderness sometimes found in light meat. These undesirable characteristics are markedly reduced by procedures which eliminate overcooking. Cooking recommendations which have been issued recently stress the same cooking time for fresh and frozen-thawed turkeys. Thus, if a meat thermometer is used, the final temperature for frozen-thawed turkeys should be about 10 degrees lower than that recommended for fresh turkeys.

Recommendations for food use developed for National programs. ARS food specialists have developed methods for preparing food that are adapted to the needs of specific population groups. The methods already have been applied in federal programs to improve the diets of low-income families and of children participating in the National School Lunch and Head Start programs. For low-income families, emphasis is on easy preparation, cooking methods that require minimum equipment, recipes with few and inexpensive ingredients, and a simple vocabulary in the instructions for persons with limited reading ability. The food requirements of preschool age children served as a guide in developing recommendations for use in Project Head Start. Simplified methods were developed for preparing food in quantity that would appeal to children and teenagers participating in the National School Lunch Program. The methods provide maximum protection from contamination with food poisoning organisms.

Pesticide residues on tomatoes markedly reduced by washing. Any pesticide residues on raw produce are at levels far below those considered safe for consumers. ARS research shows that even these acceptable, low pesticide residues are reduced on tomatoes by usual methods of preparation, cooking, and processing. Washing with cold water removed 50 percent or more of the residue on tomatoes treated with the insecticide carbaryl and approximately two-thirds of the residue on tomatoes treated with DDT. Almost all of the remaining residue was removed by commercial peeling and canning operations and by home preparation procedures. The research was done under contract with the National Cannery Association in Washington, D. C., and Berkeley, California.

These examples demonstrate how research in the Human Nutrition Division assists and can continue to assist the United States Department of Agriculture in its responsibility for producing enough food and a proper assortment of foods to meet the nutritional needs of the nation's citizens within the general framework of their food habits and for guiding consumers in their selection and use of foods.

As a step toward implementation of the recommendations for a National Program of Research for Agriculture made jointly by the Association of State Universities and Land Grant Colleges and the USDA, a section has been added to each of the Areas in this report. In future years, it is anticipated that information will be available to permit reporting of achievements resulting from State research in a format comparable to the present reporting of the USDA and cooperative research.

A total of 147.3 scientist man-years is devoted to this area of research.

Examples of research underway at the State Experiment Stations include:

Michigan - Blood Urea Levels as Influenced by Type of Dietary Protein. Proteins in wheat flour, soybeans, and casein were included separately in diets fed to rats and humans. Blood urea levels were less with wheat flour than with casein. Soybean protein did not alter the level typical of casein. These findings were not sex dependent as confirmed in two strains of rats. The reduction in blood urea occurs in rats within 4 days and in humans within 36 hours after initiation of the diet. Nitrogen absorption has been eliminated as a factor in the observed reductions. This research has implications for health conditions wherever elevated blood urea is a concern as in some kidney diseases. It suggests preferential inclusion of wheat flour over soybean flour in "bread" diets for such conditions.

Wyoming - Effect of Vitamin B₁₂ and Folic Acid on Utilization of Proteins. Rats were fed diets supplemented with vitamin B₁₂ and folic acid separately and together. Utilization of soybean protein and methionine was determined for each vitamin variable. The combination of vitamin B₁₂ and folic acid increased serum protein, liver DNA/RNA, urinary allantoin, and utilization of methionine but decreased urinary urea. Vitamin B₁₂ alone reduced activities of liver ribonuclease, succinic dehydrogenase, and glutamic dehydrogenase but elevated activity of liver glutamin-aspartic transaminase. These findings provide evidence that vitamin B₁₂ and folic acid have an interrelated role in metabolism of nucleic acids and methionine. One phase of this role is preferentially influenced by vitamin B₁₂ as a regulator of specific enzyme systems for interconversion of carbohydrate and protein.

California - Nutritional Requirements and Mammalian Development. Normal and zinc-deficient female rats and their fetuses were studied. In fetuses from zinc deficient mothers the long bones are often short or missing, lesions are evident in the esophagus, and organ malformations occur. Affected implantation sites (15 percent) and malformed fetuses (10 percent) result even when mothers are maintained on a zinc-free diet for the first 7 days of pregnancy. Juvenile rats held on a zinc-deficient diet since weaning experience hypoplasia in testicular tissues, affected ovaries, and abnormally low activity of lactic acid dehydrogenase in liver. These findings provide indices which can be used to test responses of controlled levels of dietary zinc. The research gives further evidence to a requirement for zinc.

Utah - Serum Cholesterol and Physical Characteristics of Pre-adolescents and Adolescents. Children in six schools from two counties of Utah and a selected sampling of co-siblings were studied during seven years. The 321 primary subjects included 152 girls and 169 boys, age 7-10 years at the beginning of the experiment. There were 62 sets of children in the sibling phase. Girls had significantly higher serum cholesterol than boys (free: 51.6, 48.9; total: 187, 178 mg per 100 ml). Girls showed a higher incidence of obesity but of this group more boys were persistently obese. Persistently overweight girls had higher serum cholesterol. Body-build of boys was not correlated with cholesterol level. Family patterns of cholesterol level were evident among siblings. Cholesterol levels did not fluctuate significantly from year to year in spite of change-overs in body build ratings. These findings support earlier reports that serum cholesterol is not dependent on age in this age group. It suggests a need for adopting nutrient intake practices that control serum cholesterol at an early age when indicated by clinical measures.

Mississippi - Changes in Fats and Oils During Cooking. Changes in fatty acids of cooking oils have been studied in iron and ceramic utensils. No significant difference was observed in fatty acid content of residual cottonseed oil or chicken that was fried in the two utensils. Safflower oil, corn oil, highly unsaturated shortening and cottonseed oil are being compared for degradative changes of polyunsaturated fatty acids and residues retained by potatoes during frying. This research is providing further insight to nutritive value of fried foods. It has special significance for the role of food preparation methods in atherosclerotic nutrients implicated in atherosclerosis.

Missouri - Assay Methods for Vitamin and Amino Acid Content of Foods. Microbiological methods are being developed for estimation of nutritive value of foods. Folic acid and amino acid assays with L. casei and S. faecalis have been made in corn, non-fat dry milk solids, raw and cooked flank steak. Values from the microbiological assays are compared with the chick assay method. Other vitamins have been included in earlier phases of the study. This research contributes to a collaborative study with 6 other laboratories. Findings are to be used in AOAC adoption of standard methods. Such methods extended to a wide variety of food will assist a more complete definition of nutritive value of foods.

Illinois - Microbial Content of Four Frozen Meat Products. The bacterial content of commercially frozen beef chop suey, beef stew, breaded pork patties and chicken livers was investigated. After purchase from retail stores, the products were stored at -1° C. for no longer than two weeks.

They were sampled both in the frozen "as purchased" form and in the cooked form. Of the "as purchased" samples beef stew had the lowest total count (195,000 bacteria per gram), and pork patties the highest (399,300 per gram). Coliform bacteria were found in the chicken livers and pork patties, but not in the other products. Enterococci and Staphylococci were found in all four products. Small numbers of non-coagulase-positive Staphylococci survived cooking in over one-half of the samples. Neither the coliform bacteria nor the Enterococci survived cooking. These findings demonstrate the importance of thorough cooking and strict adherence to storage directions.

New York - Digital Computer Simulation in Determining Dining Room Seating Capacity. There is an increasing interest in application of techniques developed by industrial engineers to the planning and operation of food services. In this study, a computer program was developed to simulate the operation of a cafeteria dining room. The program included in-put data on: customer group size, variation in arrival rate, seating preference for each group size, and combinations of table configurations. Results indicated that simulation permits study of the effect on a facility of changes in the parameters of the system. It, therefore, appears to be a tool that will provide management with a quantitative basis for decision-making related to food facilities.

AREA NO. 1: FUNCTIONS AND METABOLISM OF NUTRIENTS

Problem. Results from investigations of the functions and metabolism of nutrients in laboratory animals, microorganisms, and cells guide research in human nutrition and help to explain metabolic responses to diet. Only with animals of short lifespan and on controlled diets can both immediate and long-term physiological responses be measured during every stage in the life cycle and during successive generations. Studies of the morphology, biochemical composition, and physiological function of specific organ tissues, isolated cells, and cell fragments are needed to extend understanding of the functions and metabolic pathways of nutrients. The kinds, sources, and amounts of nutrients and of energy essential for growth and maintenance of body tissues and for nutritional well-being are influenced by such factors as climate, physical activity, and processes associated with reproduction, as well as by the hormone and enzyme activity that reflects heredity, aging, and sources of stress. Both qualitative and quantitative measures are needed of the extent to which these factors influence nutritional needs, metabolic response to various nutrient combinations, and physiological changes within tissues.

USDA AND COOPERATIVE PROGRAM

Investigations are underway with laboratory animals to determine the effects of nutrients and foods on growth, reproduction, and longevity, on the composition of blood and tissue, and on the structure and functioning of tissues at various stages of the life cycle. Dietary variables under study are the kinds and amounts of dietary fats and fatty acids, proteins and amino acids, carbohydrates, vitamins, and minerals. Included also are studies of interrelationships among nutrients when fed in purified form and when supplied from foods. Studies of cellular metabolism are developing new insights into functions, requirements, and quantitative relationships of nutrients important to the nutrition of man.

The program on the functions and metabolism of nutrients is conducted at Beltsville, Maryland, and under contract and cooperative agreement with private laboratories and at universities and medical schools. The studies require staff with specialized training in nutrition, biochemistry, microbiology, histology, physiology, and pathology.

The Federal scientific effort devoted to research in this area totals 17.1 scientific man-years distributed as follows: Lipids 4.8; proteins 5.2; carbohydrates 4.3; minerals 1.6; vitamins 1.2.

PROGRAM OF STATE EXPERIMENT STATIONS

A total of 59.4 scientific man-years is devoted to this area of research.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Lipids

1. Heated and oxidized fats. Research to determine the effect on physiological response of aerating fats and oils at 60° C. for 40 hours has been completed under a research contract with Columbia University at New York City. The fats constituted 20 percent of each diet with all other dietary ingredients remaining constant. In addition to the results previously reported (see 1966 report, 1-A-1, p. 2), evidence was obtained suggesting that certain fats and oils contain substances that aggravate the development of enlarged thyroids when diets contain marginal amounts of iodine. Olive oil produced a high incidence of thyroids weighing more than 100 mg., in comparison with normal thyroids of 23-31 mg. When the diet contained butter, lard, or beef tallow, the incidence of large thyroids was low. Chicken fat, soybean oil, and corn oil were intermediate in their effect on thyroid size. Thyroid size was not influenced by mild oxidation of the fat consumed.

Long-term feeding studies of diets containing fresh cottonseed oil, corn oil, lard, or hydrogenated vegetable oil or these same oils heated for 120 hours at 182° C. have been completed under contract with Swift and Company, at Chicago, Illinois. Tissue masses from the animals fed these diets were evaluated microscopically at Beltsville. Mammary tumors occurred in approximately 50 percent of the female rats, an incidence similar to that reported by others for the aging rat. Their presence appeared to be unrelated to the source of the fat fed and no differences between fresh and heated fat were observed. The incidence of non-mammary tumors was relatively low, amounting to 15 percent, too few to establish any significant dietary differences. A paper reporting these findings has been prepared for publication.

2. Insecticides and dietary fat. Under a cooperative agreement with Columbia University, at New York City, rats have been fed lard from hogs that had been fed rations containing insecticides. The lard was supplied by the Animal Husbandry Research Division. The insecticides under investigation included DDT, malathion, and heptachlor. Feeding studies have been completed and the results are being evaluated to determine the influence of the experimental rations on growth rate and on organ size, tissue structure, and insecticide content of the tissues from animals 200 and 350 days of age. See also 3-B-4; 4-B-3.

Research has continued under contract with Swift and Company, at Chicago, Illinois, to determine reproductive performance of rats fed diets which include different kinds of fats with and without a mixture of chlorinated hydrocarbons, fat soluble insecticides. Fats commonly used in food preparation were fed and include lard, cottonseed and soybean oil, and a hydrogenated vegetable fat. The level of the insecticides fed did not exceed currently accepted tolerance levels. The results already obtained with the parent and first generation indicate the importance of investigations to determine possible carry-over effects of diet to succeeding generations. Final evaluation has not been completed but there appear to be substantial differences in response to the various fats; in addition, the response to the insecticides may differ with the kind of fat fed and with the number of generations that have received the insecticide containing diet.

3. Diet and exercise. One phase of a study to determine the influence of type of diet on weight reduction has been carried out in cooperation with the University of Maryland, at College Park. Two diets which differed in their sources of energy were fed. One supplied approximately 54 percent of the calories as carbohydrate and 20 percent as fat; the other, 62 percent as fat and 12 percent as carbohydrate. These two diets were fed at two levels, ad libitum and at 65 percent of the ad libitum intake. One group of rats receiving each of these four dietary regimens was made to swim one hour daily; a second group was confined to individual cages and considered sedentary. Caloric intake was slightly higher among animals consuming the high-fat than the high-carbohydrate diet. Exercise, while reducing body weight, did not affect food intake.

The feeding of the high-fat versus the high-carbohydrate diet did not affect either the gain in body weight among animals eating ad libitum or the loss of weight that occurred when food intake was restricted. Rats that received the high-fat diet, particularly at the ad libitum level, had more body fat, less water, and a trend toward less body protein than those receiving the high-carbohydrate diet. Exercise resulted in smaller fat pads (peri-renal and epididymal) and in larger livers, hearts, and adrenals than were found in sedentary animals. Among calorie restricted groups, exercise produced a slight elevation in serum cholesterol.

A manuscript "Effects of Fat Intake and Exercise on Serum Cholesterol and Body Composition of Rats" has been accepted for publication in the American Journal of Physiology.

4. Body fat and heredity. Research has continued at Beltsville to develop, by selective breeding, strains of rats having widely different tendencies to accumulate body fat in order to determine how nutritional response may be affected by genetic factors which tend to produce obesity. Statistical analyses of the data obtained to date have been completed.

By inbreeding, two lines of rats have been obtained that differ consistently in the level of cholesterol in their blood regardless of diet. Evidence was obtained that blood cholesterol levels may be high even when the diet throughout life is low in fat and cholesterol. With this low fat and cholesterol diet, blood cholesterol was within a range considered normal in one line of rats. When the same diet was fed to the second line, blood cholesterol levels were about twice as high and reached levels sufficiently elevated to be a cause for concern. The amount of cholesterol in the liver was normal for both lines regardless of the level of blood cholesterol.

Body weight, body fat, and body measurements such as lengths, girths, and selected skinfold thicknesses were determined in three strains of rats, BHE, Wistar, and an inbred strain, all fed a low fat stock diet. From the results it was possible to develop multiple regression equations which provided a good estimation of body fat. The equations, however, were reliable only for the age, sex, and strain for which each was derived. Differences in characteristics of these rats support the concept for genetic influences in fat deposition in individuals and indicate the complex nature of the problem. Although there were significant differences in organ size among the three strains investigated, these differences were not fully explained by the differences in body size.

One paper reporting the influence of heredity on body size and on the incidence of kidney defects has been accepted for publication in *Metabolism*. Four additional papers have been submitted to scientific journals for publication.

B. Proteins

1. Immunoproteins and protein status. Research is showing how dietary protein influences the ability of the body to produce antibodies, a function of the body essential to health. A study currently underway is directed toward determining the influence of protein quality on antibody production and to learn if antibody production can serve as a measure of protein quality. This investigation is being conducted under a grant with Iowa State University at Ames. The spleen, important in the production of antibodies, decreased in weight and in number of cells when rats were fed a protein deficient diet. The reduction in antibody formation appeared to be due chiefly to a decrease in the number of cells capable of synthesizing antibody protein rather than to a reduction in the capacity of individual cells to produce antibodies. These results were reported at the meeting of the Federation of American Societies for Experimental Biology, in April 1967.

2. Aging processes in relation to dietary protein. A project has been initiated to investigate the influence of level of dietary protein and heredity on body composition, aging processes, and longevity. This project will be carried out under a research grant with Red Acres Farm, Inc., at Stow, Massachusetts. It will provide information on protein needs in relation to age and determine whether or not there are potential problems from excessive protein intake by an aging population. The extent to which heredity may be a factor in response to level of protein will be determined and should aid in understanding the variations in protein requirements of individuals.

C. Carbohydrates

1. Heredity. Research continues on the role of the carbohydrates in nutrition. Research at Beltsville is providing evidence that protein and mineral metabolism as well as lipid metabolism may differ depending on the kind of carbohydrate in the diet. Here again, the response may vary with the inherited characteristics of the animals under investigation.

During this year, four papers have been completed reporting the results of the long-term feeding of cholesterol-containing diets with the carbohydrate supplied as sucrose, glucose, and cornstarch. The findings dealing with the liver and serum lipids and the histology were described in last year's report (see 1966 report, 1-C-1, p. 5). The paper dealing with the influence of type of dietary carbohydrate on the histological findings has been accepted for publication in the Archives of Pathology. A paper dealing with the effect of dietary carbohydrate on serum protein components has been accepted for publication in the Journal of Nutrition. A manuscript on the effect of type of dietary carbohydrate and age on magnesium, calcium, and phosphorus metabolism has been prepared. A fifth paper is in preparation and will include the results on food intake, weight gain, and body composition as influenced by the kind of dietary carbohydrate.

The influence of the kind of carbohydrate on the protein components in the blood depended on age, state of fast, and strain of rat investigated. The greatest differences were observed in a protein component (PA) moving more rapidly than albumin in an electric field. The incidence, that is the relative number of rats containing this component in their blood, as well as the level of PA in the blood varied with the experimental conditions.

Differences due to dietary carbohydrate were seen more frequently in the blood obtained from rats after an overnight fast than from nonfasted animals. In one strain (BHE), level and incidence of PA increased with age in the blood of fasted animals that had received the diets containing sucrose or starch. Extremely high levels were observed with sucrose.

With glucose, the incidence was high at both 150 and 350 days of age, but the level was consistently low. In a second strain of rats (Wistar) fed sucrose, the level and incidence of PA were both high at 150 days, but low at 350 days; by 350 days no significant differences due to carbohydrate were apparent. The level of PA in the blood correlated directly with the level of fat in the blood, suggesting that this component, previously shown to be associated with fat, may play a role in fat transport.

The kind of carbohydrate also was found to influence significantly the calcium and magnesium content of the kidneys of the BHE rats. Here, too, heredity was apparently a factor in determining the extent to which levels of kidney calcium differed with dietary carbohydrate. Calcium levels were higher in the kidneys of BHE rats when the diet contained sucrose than when the diet contained starch. When sucrose was fed, the level of calcium was much lower in the kidneys of the Wistar rat than in the kidneys of the BHE rat, a strain generally susceptible to kidney damage and dying at an early age on this diet. The magnesium levels in the kidneys of both strains were higher in the animals fed sucrose than in those fed starch but no differences due to heredity were observed.

A project initiated last year under contract with the Hazleton Laboratories at Falls Church, Virginia, is progressing rapidly and close contact with the developments from this research has been possible because of the computer facilities available at the Hazleton Laboratories. This investigation is providing more information on heredity as a factor in response to diet as well as further evidence of differences in fat metabolism with the kind of dietary carbohydrate. The use of cooked cornstarch in place of the raw cornstarch that was used in our previous studies has resulted in some unexpected differences in food consumption and weight gain. The contract has been amended to include measurements of digestibility of the diets and the fecal excretion of bile acids and sterols.

2. Protein-carbohydrate interrelationships. Research using a protozoan, Tetrahymena pyriformis, with nutritional requirements and metabolic responses similar to those of higher animals, is providing further evidence concerning carbohydrate and nitrogen relationships. The marked inhibition of this organism by the amino acid serine has been found (1) to be related to type of carbohydrate, (2) to be affected by past dietary history, and (3) to be overcome as the length of the incubation period is prolonged. When the medium contains glucose, inhibition is slight; the presence or absence of glucose in previous culture media has little effect on growth response. In contrast, when the carbohydrate is dextrin, inhibition by serine is pronounced, and was greater with cultures which had previously been maintained on media containing glucose or dextrin. The inhibition is largely reversed by intermediates of the citric acid cycle, by amino acids that enter readily into this cycle, by pyruvic acid, and by glucose.

D. Minerals

Research has been initiated to determine the changes that occur in calcium metabolism with age and the effect of dietary calcium intake on these changes. This investigation will be carried out under a research grant with the University of Louisville, at Louisville, Kentucky. The factors to be investigated include calcium intake, calcium absorption, exchange between body pools, bone deposition, and urinary and fecal excretion. Information on adaptation of calcium metabolism to level of intake and the changes that occur with age should provide a sounder basis for predicting calcium needs throughout life than is currently available.

E. Vitamins

Research has been initiated to determine the influence of excessive intakes of certain vitamins by the mother on pre- and post-natal development of the young. This research will be carried out under a research grant with Massachusetts Institute of Technology at Cambridge. The three vitamins to be studied are vitamin A, B₁₂, and biotin, all important to normal cell growth. Information also will be obtained on the effects of these early stresses at various periods throughout life.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Lipids

Dupont, J. 1966. Synthesis of cholesterol and total lipid by male and female rats fed beef tallow or corn oil. *Lipids* 1, 409-414.

Kaunitz, H. 1966. Zur molekularen Biologie der Triglyceride. *Wiener klinische Wochenschrift* 78, 680-683.

Kaunitz, H., Johnson, R. E., and Pegus, L. 1966. Longer survival time of rats fed oxidized vegetable oils. *Proc. Soc. Exp. Biol. Med.* 123, 204-206.

Kaunitz, H. 1967. Nutritional aspects of thermally oxidized fats and oils. *Food Tech.* 21, 60-64.

Kaunitz, H. and Johnson, R. E. 1967. Thyroid and pituitary pathology in iodine-deficient rats fed fresh and oxidized fats and oils. *Jour. Nutr.* 91, 55-62.

Proteins

Datta, R. K., Chakrabarty, P. R., Guha, B. C., and Ghosh, J. J. 1966. Studies on leaf proteins-preparation of protein concentrate from leaves of water hyacinth. *Sci. and Cult.* 32: 247-249.

- Datta, R. K., Chakrabarty, P. R., Guha, B. C., and Ghosh, J. J. 1966. Protein concentrates from leaves of water hyacinth. Indian Jour. Appl. Chem. 29: 7-13.
- Guggenheim, K., and Szmelcman, S. 1966. Protein-rich preparation based on soybean flour, sesame flour and chick peas. II International Congress Food Sci. and Tech., Warsaw, p. 24 (Abstract).
- Rajalakshmi, R., and Ramakrishnan, C. V. 1966. Protein nutrition and brain functions. Presented at VII International Congress of Nutrition, Hamburg, Germany, August.
- Kenney, M. A., Arnrich, L., Piedad, F., and Roderuck, C. E. 1967. Effect of protein depletion on the spleen and antibody formation. Fed. Proc. 26, Abstract No. 856.
- Rajalakshmi, R., Ali, S. Z., and Ramakrishnan, C. V. 1967. Effect of inanition during neonatal period on discrimination learning and brain biochemistry in the albino rat. Jour. Neurochem. 14: 29-34.

Carbohydrates

- Ahrens, R. A., and Wilson, J. E., Jr. 1966. Carbohydrate metabolism and physical activity in rats fed diets containing purified casein versus a mixture of amino acids simulating casein. Jour. Nutr. 90: 63-70.
- Reynolds, H. 1967. Effect of type of carbohydrate on growth inhibition of *T. pyriformis* by serine. Jour. Am. Soc. Microbiology. Bacteriological Proceedings, page 35. (Abstract)
- Taylor, D. D., Conway, E. S., Schuster, E. M., and Adams, M. 1967. Influence of dietary carbohydrates on liver content and on serum lipids in relation to age and strain of rat. Jour. Nutr. 91: 275-282.

Vitamins

- Chatterjee, G. C. 1967. Biochemical detection of ascorbic acid deficiency. Effects of ascorbic acid deficiency in animals. Ascorbic acid requirements of microorganisms. Ascorbic acid requirements of animals. Vol. I. The Vitamins. 2nd Ed., 570 pp.
- Rajalakshmi, R., Malathy, J., and Ramakrishnan, C. V. 1967. Effect of dietary protein content on regional distribution of ascorbic acid in rat brain. Jour. Neurochem. 14: 161-168.

Nutrient Interactions

- Womack, M., Ahrens, R. A., and Wilson, J. E., Jr. 1967. Effects of long-term feeding of milk and milk components to rats. Jour. Dairy Sci. 50: 509-517.

AREA NO. 2: HUMAN METABOLISM AND REQUIREMENTS FOR NUTRIENTS

Problem. Research in human metabolism aims to determine the kinds and quantities of foods and nutrients needed by individuals for nutritional well-being, and the factors that influence nutritional needs. Systematic biochemical and physical observations of persons on controlled diets provide information on the use of nutrients in the body in relation to age, activity and environmental conditions; and on the quantities of nutrients and food energy required by persons of different ages, by those accustomed to different food patterns, or living under different environmental and nutritional conditions. The absorption, transport, and metabolism of individual nutrients and groups of nutrients are investigated. Results of this research aid in defining average human requirements for nutrients and for food, and in establishing the lower and upper limits of nutrients and of food combinations conducive to human well-being. Studies also are made of the specific requirements and nutritional status of individuals. Such information is needed to assure the optimal utilization of our food resources and provides a basis for programs for improving nutrition. Application of such knowledge will influence food habits, the general state of nutrition and health, market demand for commodities, and the orientation of agricultural production.

USDA AND COOPERATIVE PROGRAM

USDA research on human metabolism places major emphasis on determining the quantities of nutrients required by persons of different ages on controlled diets, on measuring the metabolic behavior of individuals with regard to several nutrients at the same time, and on determining the availability and physiological utilization by man of nutrients from diets. The current program deals particularly with factors affecting the metabolism of carbohydrate and protein and the range in biochemical response among individuals. Measurements are made on intake of nutrients, output and levels in the blood of metabolic products, and other criteria available in the living organism. Systematic compilation and reevaluation of all available knowledge on subjects of special nutritional significance are made to indicate gaps which should be filled by research and to suggest the most promising areas for new research.

The program is carried out in the laboratories at Beltsville, Maryland, through contracts, grants, and cooperative agreements with universities and medical schools, and through participation in Regional Projects of the State Agricultural Experiment Stations. Nutritionists, biochemists, physiologists, physicians, and statisticians cooperate in the program.

The Federal scientific effort devoted to research in this area totals 2.7 scientific man-years distributed as follows: Nutritional requirements 0.6; nutritional value of foods 1.7; nutritional status 0.4.

PROGRAM OF STATE EXPERIMENT STATIONS

A total of 28.6 scientific man-years is devoted to this area of research.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Nutritional Requirements

1. Preadolescents. The compilation of data obtained on the metabolic responses of 36 girls, 7 to 9 years old, eating controlled diets is to come off the press in July of 1967. The studies were carried out between 1954 and 1958 under Southern Regional Nutrition Research Project S-28. The data include information on nutrient intake, energy expenditure, skeletal and body surface measurements, blood composition, and nutrient excretion in urine and feces. The compilation will serve as a ready reference of baseline data for comparison in other studies of this age group.
2. Adolescent girls. The data obtained in a study to measure the metabolic response of adolescent girls to a controlled ovo-lacto-vegetarian diet have been analyzed statistically. A manuscript reporting the results is in preparation. In this study, under a research contract with Andrews University at Berrien Springs, Michigan, 16 girls, 17-19 years old, ate a controlled diet for 25 days. Intake and excretion of nitrogen, fat, calcium, phosphorus, and magnesium, serum levels of cholesterol, phospholipids, glycerides, and total fatty acids were measured. All girls were in positive nitrogen balance on intakes of 64 grams protein per day. Calcium balances showed that the girls (average age 18 years) had requirements that could be met by the NRC recommended allowance of 1.3 grams calcium for older adolescents (17 and 18 years) but not by the lower allowance of 0.8 grams for 18-35 year old women. Small positive magnesium balances achieved on 320 mg magnesium/day indicated the probable need for an upward revision of the intake level currently believed to be adequate for maintenance.
3. Magnesium requirements of adolescent boys. The magnesium requirement of adolescent boys is the subject of study under contracts with the University of Wisconsin at Madison and the University of Connecticut at Storrs. At Wisconsin, six adolescent boys, 17-18 years old, have been subjects in two dietary studies. In these studies, 6 test diets were included; a basal low protein (45 gms protein/day) and a basal high protein (135 gms protein/day) diet were each fed with three levels of

magnesium (3.5, 7.0, and 10.5 mg magnesium per kilogram body weight). No two subjects were on the same test diet during a given period. Each study consisted of a 10-day stabilization period and three test periods of 15 days each. Blood samples were drawn at the beginning of the study and at the end of each test period. Analyses have been made for urea, serum ribonuclease, alkaline phosphatase, and lactate dehydrogenase, and for red blood cell magnesium. Additional analyses of blood, food, feces, and urine are in progress. At Connecticut, diets have been planned and analyzed and preparations are being made to run the first of a series of two metabolic studies in their longitudinal study with 13-16 year old boys. The diets will provide daily intakes of magnesium of 3.5 or 10.5 mg per kilogram body weight and 0.1 or 0.25 gm nitrogen per kilogram body weight. Measurements will include nitrogen and magnesium balance, serum levels of magnesium, and selected enzymes, as well as protein and amino acids.

4. Review of present state of knowledge of human requirements. Plans have been made to conduct a critical review of current knowledge of human requirements for nutrients. The review will be made in cooperation with the School of Public Health at Harvard University. A senior staff scientist of the Division will be stationed at Harvard to participate in the study. Published information on requirements for selected nutrients will be critically reviewed, analyzed, and summarized. Consideration will be given to the needs of various age groups of each sex. Areas for which there are insufficient data or a lack of knowledge will be identified. The findings will serve as a basis for establishing priorities and planning future research programs.

B. Nutritional Value of Foods

1. Evaluation of wheat. Contract research on the nutritional value of wheat protein has been completed and manuscripts giving the results are being prepared for publication. At Michigan State University, 12 young men achieved nitrogen balance on diets supplying approximately 66 grams protein per day, all from plant sources and 90-95 percent of which was provided by wheat. During the 50-day study, protein components in the blood were not changed significantly. However, the blood urea level was reduced by approximately 50 percent on the wheat diet, with a gradual reduction in urinary urea excretion. Urinary excretion of essential amino acids was related to dietary intake. Fasting plasma free amino acids were within normal limits throughout the study. The plasma levels of lysine and valine were reduced during the first 25 days on the wheat diet and remained constant thereafter. The reduction in plasma lysine may be attributable to a reduction in dietary lysine. The reduction in valine took place despite the constancy of its intake with both the prestudy mixed protein diet and the controlled wheat diet. The reduction, therefore, may be reflecting lower availability of valine in the wheat diet. There was no significant change in serum levels of total lipids, cholesterol, or phospholipids.

Vitamin and mineral analyses were completed at the Agricultural and Technical College of North Carolina, Greensboro, where 12 young men were maintained in positive nitrogen balance during four 15-day test periods on diets containing 47 grams plant protein per day, of which 35 grams (75 percent) were supplied by wheat or wheat supplemented with pinto beans, rice, or peanuts. The analyzed dietary intake of niacin as determined microbiologically was approximately half of the calculated content. The analyzed daily dietary intakes of vitamins B₆ and B₁₂ were both much lower than the calculated values and as a result, the intakes were lower than suggested by the National Research Council as minimal. During the short duration of the study, these low intakes appeared inconsequential. These differences in analyzed and calculated values reflect the variation in vitamin content within food groups and illustrate how nutrient content may vary from the weighted average values given in tables of food composition. No information on the significance of dietary changes on vitamin and mineral metabolism will be available until the contractor has analyzed the data statistically. During the year, portions of this research were presented at the International Congress of Nutrition, Hamburg, Germany, in August 1966, and at the Federation of American Societies for Experimental Biology in Chicago, Illinois, April 1967. A manuscript giving the results is being prepared for publication.

2. Metabolic response to form of dietary carbohydrate. A dietary study with 10 young men (19-23 years old) was conducted to compare the nutritional value of wheat starch with sucrose. In this study, the young men ate diets identical in composition to those in an earlier study of young women and reported in the 1966 Report (2-B-3, p. 17). In these diets, 85 percent of the carbohydrate was provided by wheat starch or sucrose during 30-day dietary periods. To meet the greater nutrient needs of the young men, the quantity of all foods in the diet was increased by approximately 50 percent over the quantity eaten by the women. The men's serum levels of lactate dehydrogenase, alkaline phosphatase, aldolase, and the two transaminases were significantly higher with the sugar diet than with the starch diet. Most of the levels observed were within the normal range for the enzyme under study. The levels of aldolase were in the border-line area (slightly above normal) in three subjects initially, in two subjects after eating the starch diet, and in seven subjects after eating the sugar diet. The significance of these observations is not clear at present, but it seems likely that starch and sugar were metabolized by different pathways or at different metabolic rates or both. A portion of this research was reported at the Federation of American Societies for Experimental Biology in Chicago, April 1967. A manuscript is being prepared.

To help explain some of these observations, research on the early metabolic effects of different kinds of carbohydrates upon various components of blood and urine of men and women has been initiated under a grant at the University of Alabama at University. The carbohydrates proposed for study

include glucose, fructose, sucrose, wheat starch, and cornstarch. Blood will be analyzed for changes in enzymes such as lactate dehydrogenase and its isozymes and for carbohydrate metabolites such as glucose and pyruvic acid for several hours following the test meal. Urine will be analyzed for various nitrogenous components and mineral elements.

Scientists in Israel, supported by a PL 480 grant from USDA, have extended their research on the influence of the kind of carbohydrate on fat and cholesterol in the blood to include fructose in addition to glucose, sucrose, and cornstarch. They also are investigating subjects with normal levels of fat and cholesterol in their blood as well as those with abnormally high levels of both. Only certain subjects responded with marked changes in the triglyceride and cholesterol levels in the blood when different mono- or disaccharides were interchanged with starch. A possible derangement in carbohydrate or fat metabolism by these subjects is suggested. The kind of differences observed are in line with those found in investigations currently underway in the Division with different strains of rats and may well be related to inherited traits of the subjects.

C. Nutritional Status

1. Preschool children in Hawaii. Under cooperative agreement with the Consumer and Food Economics and the Human Nutrition Research Divisions, scientists at the University of Hawaii are studying the nutritional status of preschool children in families of two income levels. Data collected in biochemical, clinical, and psychomotor tests are being evaluated.

2. Children in Mississippi Delta. In May 1967, the USDA made a study of the effectiveness of food aid programs in two Mississippi Delta counties. An analysis of the dietary situation of the 509 families represented in the survey was conducted by the Consumer and Food Economics Research Division. In this cooperative study, height and weight for age was measured as an index of nutritional status of the children. These included 401 boys and girls, 2 to 12 years old, in Washington and Sunflower counties. The children in families that were participating in the Food Stamp Plan or the Food Donation Program were compared with the children in families that were not participating in any food program.

Children in participating families were no different in height and weight for age than children in nonparticipating families. In height, 36 percent of the children were above average for their age, 22 percent were average, and 42 percent were below average for their age when compared with reference standards for U. S. children. In weight, 44 percent of the children were above average for their age, 30 percent were average, and 26 percent were below average. When weight was related to height, 44 percent of the children were above average weight for their height, 36 percent were average weight for height, and 20 percent were below average weight for height.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Nutritional Requirements

- Roe, Kwang Sew, and Kim, Dong Jun. 1964. Studies of the daily energy expenditures of Korean laborers in agriculture and construction. Jour. Korean Modern Med. 1: 51-64.
- Kim, Ku Ja. 1965. Studies on basal metabolism, calorie expenditures and daily energy expenditures of Korean students in middle school, high school and college. Jour. Korean Modern Med. 3: 271-294.
- Rajalakshmi, R., Subbulakshmi, G., Ramakrishnan, C. V., Joshi, S. K., and Bhatt, R. V. 1967. Biosynthesis of ascorbic acid in human placenta. Current Sci. (India) 36: 45.

Nutritional Value of Foods

- Fry, P. C., Leverton, R. M., and Goksu, S. 1966. Growth of Hong Kong children--on diets containing rice or rice and wheat with and without nutrient supplements. 11th Pacific Sci. Cong., Tokyo, Proc. Vol. 8, Sec. on Nutr. in the Pacific area, p. 30.
- Ganapathy, S., Booker, L., Rumph, C., and Edwards, C. 1966. Plasma amino acid content of young men receiving diets containing wheat and wheat supplemented with pinto beans, rice or peanut butter. Presented at the 7th International Congress of Nutrition, Hamburg, Germany, August.
- Guggenheim, K., and Szmelcman, S. 1966. Protein-rich preparation based on soybean flour, sesame flour and chick peas. II International Congress Food Sci. and Tech., Warsaw, p. 24 (Abstract).
- Kaufmann, N. A., Poznanski, R., Blondheim, S. H., and Stein, Y. 1966. Effect of fructose, glucose, sucrose and starch on serum lipids in carbohydrate induced hypertriglyceridemia and in normal subjects. Israel J. Med. Sci. 2: 715.
- Yang, T. H. 1966. Nutritional evaluation of diets containing varying proportions of rice and sweet potatoes. Presented at 11th Pacific Sci. Cong., Tokyo.
- Ganapathy, S., Booker, L., Rumph, C., and Edwards, C. 1967. Effect of diets containing wheat and wheat supplemented with pinto beans, rice, or peanut butter on the excretion of B-complex vitamins in urine of young men. Federation Proceedings 26, No. 2, 306 (Abstract).

- Irwin, M. I., and Staton, A. J. 1967. Serum enzyme levels of young men as affected by diets containing starch or sucrose. Federation Proceedings 26, No. 2, 305 (Abstract).
- Kaufmann, N. A., Poznanski, R., Blondheim, S. H., and Stein, Y. 1967. Comparison of effects of fructose, sucrose, glucose and starch on serum lipids in patients with hypertriglyceridemia and normal subjects. Amer. Jour. Clin. Nutr. 20: 131-132.

AREA NO. 3: NUTRIENT COMPOSITION OF FOODS

Problem. The nutritional value of foods to man represents the combined results of the proportion and form of nutrients as found in single foods or as combined with others in the ordinary diet. This knowledge is essential for estimating the dietary contribution of individual foods and the nutritional adequacy of diets of population groups. Analyses of foods by chemical and physical means indicate potential nutritive value. Included are the influences of agricultural chemicals such as pesticides on food nutrients. Data on both cooked and raw foods are needed to determine the effects of household and institution preparation methods upon the nutrients in foods and to derive realistic figures for nutritive value of diets.

USDA AND COOPERATIVE PROGRAM

Foods, representative of various production sites and practices, and of various processing and marketing procedures, are analyzed as purchased from the market and as prepared for eating by the consumer. Analyses are made for many nutrient components including amino acids, fatty acids, carbohydrates, minerals, and vitamins. Values for calorie, protein, and fat content are derived from analyses made of the proximate composition. Methods are developed for newly identified nutrients and forms of nutrients; existing methods for known nutrients are improved and adapted for use with different foods. The forms in which nutrients occur in foods are identified. The chemical and physical properties of these forms are established and related to their biological availability and the nutritive value of foods. The research is conducted at Beltsville, Maryland, and under contract and cooperative agreement in the laboratories of universities and industry. Chemists, biochemists, biologists, and statisticians participate in the program.

The Federal scientific effort devoted to research in this area totals 10.0 scientific man-years distributed as follows: Horticultural crops 1.5; animal products 0.5; grain and grain products 6.6; protein and amino acids 1.4.

PROGRAM OF STATE EXPERIMENT STATIONS

A total of 22.5 scientific man-years is devoted to this area of research.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Horticultural Crops

1. Mineral element content of fruits. Studies on the content of individual mineral elements in fresh fruits were completed. Samples of known origin were purchased from the Washington, D. C. market. Production areas extended from New England to California. Ecuador, Honduras, Hawaii were some of the producing areas outside the continental United States. Thirty fresh fruits were analyzed for eleven mineral elements, total ash, and total solids. Sample variation within a producing area was greater than the variation among different producing areas. Manganese and sodium content exhibited the largest area variation, the highest being a 23-fold range (38 to 888 micrograms per 100 grams) for the manganese content of bananas grown in Jamaica and a 12-fold range (3.16 to 36.49 milligrams per 100 grams) for the sodium content of winter varieties of avocados grown in California. Among producing areas, only rhubarb and avocado exhibited differences in total solids, ash, fat (avocado only), and sodium large enough to be nutritionally important. In addition, rhubarb from the various producing areas differed in nitrogen, aluminum, calcium, copper, potassium, and phosphorus. A manuscript reporting these data has been accepted for publication in the Journal of the American Dietetic Association.

2. Effect of herbicides on fruit sugars. Carbohydrates were determined in apples, blueberries, and peaches grown on soils treated with different herbicides. Diuron, simazine, CIPC (isopropyl N(3-chlorophenyl)carbamate) and amitrole were used in the apple orchards; diuron and simazine were used on soils for blueberries and peaches. Apples and blueberries from the 1965 and 1966 seasons were examined, but peaches only from the 1966 harvest. Analyses were made for total solids, total and reducing sugars, sucrose, glucose, and fructose. In only one case did the herbicide treatment significantly affect sugars. The peaches grown on soils treated with simazine at 4 pounds per acre were significantly higher than others in sucrose, 6.8 as compared with an average of 6.3 percent. This finding agreed with taste panel results. These peaches scored highest in flavor. Differences between crop years in the amount of sugars in apples and in blueberries were greater than the differences among herbicide treatments. A manuscript has been prepared for publication (see 4-A-1).

B. Animal Products

1. Lipids of raw and cooked beef and pork. Cooking of ground beef or pork patties did not greatly change the fatty acid composition according to studies done under a research contract at the University of Tennessee

at Knoxville. Analyses were made of the extracted lipid from raw meat, cooked meat, and drippings. The lipids were separated into neutral fat and phospholipid fractions. Polyunsaturated fatty acids were largely in the phospholipid fraction; cooking increased the phospholipid concentration of the ground meat. This could be explained by the loss of larger amounts of neutral fat to the drippings, causing an apparent gain in phospholipid in the cooked beef or pork. However, the beef and pork were relatively low in phospholipid, less than 5 percent of the total fat or less than 1 percent of the meat, and were also low in unsaturated fatty acids.

Studies under contract at the University of Wisconsin at Madison on the fatty acid composition of beef are continuing. Biopsy samples of the longissimus dorsi muscle of fifteen animals were taken at 12 months of age and at 2 month intervals thereafter. These data showed an increase in extractable intramuscular lipid, largely in the neutral fat rather than phospholipid fraction, as the animals increased in age and weight. A paper based on part of these studies was prepared to be given at the August 1967, meeting of the American Society of Animal Science. In addition, fatty acid analyses of raw and cooked cuts from 6 out of the 12 animals planned for the study have been processed. Slaughter weight was about 1000 pounds live weight.

Data have been obtained from 10 of the 24 pigs planned for the study of the fatty acid composition of uncooked and cooked fresh and cured pork, done under contract at the University of Missouri at Columbia. Cooking decreased the unsaturated fatty acids of the phospholipid fraction of lean pork. Results of these studies on 9 animals were submitted in a thesis at the University of Missouri Graduate School in partial fulfillment for a Master's degree.

2. Composition of lamb. Raw and cooked leg and rib-loin cuts of lamb showed an increase in relative amounts of separable fat and drippings with an increase in weight of cut. Separable lean contained about 90 percent of the protein and moisture of the entire cut, but only about one-quarter of the total lipids. The lean also contained most of the ash. Altogether 60 cuts each of raw and roasted lamb from 118 animals of different ages were analyzed. Cuts were separated into lean, fat, bone, and waste. Drippings from the cooked cuts were included. Analyses were made for moisture, protein, fat, and ash. Amino acids were determined in lean tissue only. Two manuscripts were published: one on the physical and chemical composition of lamb cuts and the other on the amino acids of raw and cooked separable lean tissue.

3. Extraction of lipid from beef. A study was made to select the best method for extracting lipids from meat samples. Meat lipids were more completely extracted by chloroform-methanol than by either acid hydrolysis or Soxhlet extraction with volatile solvents. Comparisons were made both of total lipid and of phospholipid extracted. Variations in sample preparation such as freeze drying, vacuum or air drying, grinding, or grinding and homogenizing did not affect the extraction of lipids. Acid hydrolysis resulted in a decrease in the total amount of extractable lipids and phospholipids. The manuscript reporting these studies was published.

4. Nutrients in cheeses and dairy products. A study has been initiated on the nutrients in cheeses and other milk products. The study, in which the Consumer and Food Economics Research Division is cooperating, will be done in three parts. Part one includes products from fresh whole milk such as dried whole milk, fluid skimmed milk, dried skimmed milk, cottage cheese and whey, cream and cream cheeses, and the original milks from which the products were made. Plans are to repeat the study in two geographic locations and in each of two seasons.

In part two, cheeses of the American type cheese; i.e., Cheddar, stirred-curd Colby, Swiss; Italian types of cheese; i.e., pizza or low moisture Mozzarella, Provolone, Ricotta, and Blue cheeses are to be obtained in two seasons. The milks from which the cheeses were made and the resulting wheys will also be obtained and analyzed.

In part three, natural and processed cheese available to the consumer in markets in each of six widely separated locations in the United States will be obtained. At any location three common or usual brands of the particular cheese will be combined. Proposed for multinutrient analyses are hard cheese; i.e., Cheddar, Colby, Swiss, Provolone; semisoft cheese; i.e., Blue, Brick, Meunster; soft cheese; i.e., Cottage cheese, cream cheese, Ricotta, Camembert, Neufchatel, low moisture Mozzarella (pizza cheese); and processed cheese; i.e., American, Brick, and Swiss. The nutrients to be assayed include cholesterol, individual fatty acids, vitamin A, carotene, several B-vitamins, mineral elements, and the individual amino acids. The samples will be procured and the analyses made by Hazleton Laboratories at Falls Church, Virginia.

C. Grain and Grain Products

1. Nutrients in wheat and wheat products. Studies of the nutrient content of wheats and wheat products, collected from 10 cities representative of the continental United States, continue at Beltsville and under research contracts with the American Institute of Baking at Chicago, Illinois, and with the Purdue Research Foundation at Lafayette, Indiana. Analyses for the individual fatty acids and for carbohydrate fractions have been

completed. Analyses for riboflavin, thiamine, vitamin B₆, tocopherols, and for at least five mineral elements will soon be completed. Manuscripts reporting the source and preparation of samples, the results of analyses for fatty acid, carbohydrate fractions, tocopherols, some of the B-vitamins, and on at least five mineral elements will be prepared and processed during the coming year. Laboratory work on forms of niacin, amino acids, and on trace mineral elements are in progress.

As expected, soft white wheats used for cake and cracker flour were found to be lowest in nitrogen. Hard red winter type wheats used for bread flour were one-fourth higher in nitrogen than the soft white wheats, and durum wheat for macaroni and noodles were one-third more. The starch contents of these wheats were in the reverse order, but not by the same amounts. The riboflavin contents of the wheat grains were very much alike. Durum flour, however, was two to three times higher in riboflavin than other flours. Few differences were observed in fatty acid profiles of the same kind of wheat products from different locations. The kind of shortening used was a large factor influencing these fatty acids in commercial prepared products. Continuous dough bread was higher in linoleic and linolenic acids than conventional dough bread. Some other minor differences in fatty acids were found. The whole wheat products on the retail market were two to eight times greater in copper, manganese, magnesium, and zinc than refined flours or their products. Nickel in hydrogenated shortenings may account for variations in nickel. Nickel was highest in biscuit mix, 0.7 micrograms per gram, and lowest in flours and whole wheat cereals, about 0.2 micrograms. Nickel varied more than other elements in the wheat products analyzed.

The tocopherols are nutritionally important, both because of their vitamin E potencies, and because of their antioxidant activities. Alpha tocopherol has the highest vitamin E potency. The forms and amounts of the tocopherols were similar in all wheat grains, the alpha tocopherol content being about 14 micrograms per gram. Durum wheat was slightly lower in alpha and beta tocopherols, and higher in their unsaturated analogs. More refined flour contained less tocopherol. Cake flour treated with benzoyl peroxide and chlorine contained no alpha tocopherol, and only minor amounts of beta tocopherol and beta tocotrienol. Major differences in kinds and amounts of tocopherols in baked products were due to the contributions of ingredients other than flour, especially the shortening used. For example, cake was found to contain 30 micrograms of delta tocopherol per gram, 76 of gamma, and 12 of alpha, all from the shortening, plus 2 of beta tocotrienol from the flour. Products made with animal or vegetable shortenings were easily distinguished. Crackers had the greatest variety of forms of tocopherols, containing alpha, beta, gamma, and delta tocopherols, as well as beta tocotrienols. There were wide variations

among market areas in the tocopherols in the consumer wheat products, but again these were principally due to the shortening used. For instance, gamma tocopherol in biscuit mix varied, apparently at random, from 0.2 to 66.0 microgram per gram. Wheat has no gamma tocopherol.

In searching for a suitable internal standard to use in tocopherol analyses, a large number of high molecular weight polyesters were prepared and their gas-liquid chromatography retention data determined. This information permits the choice of the best internal standard for a particular sample.

Nuclear magnetic resonance was used to characterize structural details peculiar to the different tocopherols, distinguishing them from one another and from other related compounds. Procedures for the characterization of tocopherols were presented at the 1966 fall national meeting of the American Chemical Society; a manuscript has been published in the Journal of Organic Chemistry.

The vitamin B₆ in whole wheat, whole wheat products, flour, and macaroni occurred mainly as pyridoxine. Baked products contained not only pyridoxine, but equal or greater amounts of pyridoxal and pyridoxamine. Conventional dough bread and continuous dough bread were equal in vitamin B₆ content. Durum wheat was highest in vitamin B₆, containing 3.9 micrograms per gram; hard winter wheats, 3.1, and soft white wheats, 2.8. The vitamin B₆ value in durum flour was twice that of flour from hard red or soft white wheat. Whole wheat is an important source of vitamin B₆ in the diet.

2. Wheat fumigation. No great differences attributable to use of fumigants on stored wheat are apparent in the nutrient content of wheat grain, milling fractions, doughs, or baked products. In a cooperative study, the wheat has been stored in bins in Kansas at atmospheric temperature since the spring of 1965, subject to periodic cleaning and fumigation. Nonfumigated wheat has been stored under the same conditions where it became heavily infested with insects, and also in refrigerated storage (32°) where it remains in good condition. Little accumulation of fumigant residues occurred except for the wheat fumigated with methyl bromide. After 18 months, inorganic bromide in the whole wheat grains has increased ninefold, elevenfold in the patent flour, and tenfold in the baked bread. This indicates that bromine residues are not limited to the surface of the grain. Generally, the tocopherol content of the whole wheat did not change with storage or due to the fumigation treatment. However, some differences in tocopherols and B-vitamins of milling fractions were observed. Further analyses and treatment of the data are needed before final interpretations are made. Storage of the wheat will be terminated in March 1968 after almost three years (see 4-D-2).

3. Retention of lysine used to fortify wheat flour. Studies were made to determine whether free lysine added to wheat flour would be lost during baking. Flours with no added lysine (as control) and flours to which lysine hydrochloride had been added at 0.1 to 0.6 percent levels were used in making doughs, chapatis, and breads. Only 3.8 percent of the added lysine was lost on cooking chapatis, while in bread the loss was 25 percent. The larger loss upon baking bread may be due to the much greater cooking time (see 4-D-1).

D. Protein and Amino Acid Components

1. Methionine-carbohydrate reactions. A compound was synthesized by reacting methionine with glucose as a model for the study of methionine-carbohydrate reactions occurring during the heat processing of foods. In foods such a reaction is thought to be responsible for lessened methionine availability. The synthesized compound was found to have a lesser availability to L. mesenteroides P 60, a lactic acid producing microorganism, than an equivalent quantity of methionine.

2. Nuclear magnetic resonance of amino acids. The rotational conformations of amino acids are known to be of significance in their nutrient role in biological systems. Means of determining this physical property with some reliability have been the subject of much research. A promising tool is nuclear resonance, which is a physical method for probing molecular environments by tuning into the radio-frequency responses of nuclei. Studies were undertaken to provide fundamental information on the capabilities and limitations of the technique. Model compounds were found to provide significant insights regarding the relation of nuclear resonance parameters to rotational free energies. A paper reporting the research was prepared for presentation and was published in the abstract of the 1967 spring national meeting of the American Chemical Society.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Horticultural Crops

Murphy, Elizabeth W., Marsh, Anne C., White, Katrine E., and Hagan, Susie N. 1966. Proximate composition of ready-to-serve potato products. J. Am. Diet. Assn. 49: 122-127.

Eheart, J. F., and Mason, B. S. 1967. Sugar and acid in the edible portion of fruits--samples from the wholesale market. J. Am. Diet. Assn. 50: 130-132.

Animal Products

- Blum, Amos E., Lichtenstein, Harold, and Murphy, Elizabeth W. 1966. Composition of raw and roasted lamb and mutton. II. Amino acids. J. Food Science 31: 1001-4.
- Murphy, Elizabeth W., Toepfer, Edward W., Marsh, Anne C., and Hagan, Susie N. 1966. Composition of raw and roasted lamb and mutton. I. Physical and proximate composition. J. Food Science 31: 994-1000.
- Batcher, O. M., Murphy, E. W., Dawson, E. H., Marsh, A. C., Hagan, S. N., and Deary, P. A. 1967. Composition and palatability characteristics of mild-cured hams in relation to heating, cover fat, and marbling. Food Technology 21: 156A-159A.
- Campbell, A. M., and Turkki, P. K. 1967. Lipids of raw and cooked beef and pork. Contract with Univ. of Tenn., supported in part by Human Nutrition Research Division. J. Food Science 32: 143-146.
- deLumen, Benito O. 1967. The fatty acid content and composition of raw and cooked pork. Masters thesis. University of Missouri. June.
- Hagan, S. N., Murphy, E. W., and Shelley, L. M. 1967. Extraction of lipids from raw beef lean using various solvent systems. J. Assn. Official Analyt. Chemist 50: 250.

Grain and Grain Products

- Eheart, James F., and Mason, Blanche S. 1966. Assay methodology studies of carbohydrate fractions of wheat products. J. Assn. Official Analyt. Chemist 49: 907-912.

General

- Finegold, Harold, and Slover, Hal T. 1966. Spectroscopic studies of aromatic isoprenoids. ABSTRACTS. 152nd Meeting, American Chemical Society. Abstract No. A-082.
- Finegold, Harold. 1967. Nuclear magnetic resonance studies of some saturated heterocyclic systems. ABSTRACTS OF PAPERS. 153rd Meeting, American Chemical Society. Abstract No. O-075.
- Slover, H. T., Shelley, L. M., and Burks, T. L. 1967. Identification and estimation of tocopherols by gas-liquid chromatography. J. Am. Oil Chemists Soc. 44: 161-166.

Oilseeds and Peanuts

Ikehata, H., Otsyki, K., and Murata, K. 1965. Studies on fermented soybeans. Tempeh (IV) Modified method of isolation of hemolysis-preventing factors. Paper presented at 19th Annual Meeting Japanese Soc. Food and Nutrition.

Murata, K., and Ikehata, H. 1966. Hemolysis preventing antioxidant activity of synthesized 6.7.4-trihydroxyisoflavone and that isolated from tempeh. Paper presented at VII International Congress of Nutrition, Hamburg, Germany.

Murata, K. 1966. Changes in B-vitamins of tempeh during fermentation. Paper presented at 164th Vitamin B Research Committee Meeting, January.

Murata, K. 1966. Studies on fermented soybeans, tempeh (V). Paper presented at Agr. Chem. Soc. of Japan, April.

Murata, K., and Miyamoto, T. 1967. Studies on fermented soybeans, tempeh. VII. Antioxidant activity of 6.7.4-trihydroxyisflavone. Paper presented at Agr. Chem. Soc. of Japan, April.

Murata, K., Miyamoto, T., and Kokufu, E. Studies on fermented soybeans, tempeh. VIII. Biotin and folic acid contents of tempeh. Paper presented at Japanese Soc. of Food and Nutr., May 1967.

AREA NO. 4: FOOD PROPERTIES RELATED TO QUALITY AND CONSUMER USE

Problem. Food properties are altered by heating, chilling, freezing, aeration, physical manipulation, storage, and other practices which comprise household and institutional processes of food handling. The quality characteristics of fruits, vegetables, meats, poultry, dairy products, eggs, fats, flour, and cereals depend upon the chemical composition, physical structure, and biological systems characterizing the raw food and the changes induced by preparative procedures. Relationships should be established between the composition and structure of raw and cooked food and those qualities important to the consumer, including ease of handling, perishability, economy of yield, physical appearance, palatability, general consumer satisfaction and nutritive value. Methods of food storage, handling, and preparation designed to minimize dangers from food poisoning are required. Such data are fundamental to developing household and institutional methods of food processing and preparation which permit optimal use of available food supplies and consumption of food for good nutrition.

USDA AND COOPERATIVE PROGRAM

Knowledge of the inherent chemical composition, physical properties, and biological systems in raw and processed foods is obtained to provide basic criteria for determination of those characteristics responsible for palatability and functional behavior of foods during consumer use. Principles are established and improved procedures developed for household and institutional food preparation, care, and preservation. These procedures are designed not only to optimize quality but to minimize dangers from excessive pesticidal residues and microbiological contamination. The research is carried out along commodity lines such as fruits, vegetables, grain and dairy products, meat, poultry, and eggs. Specialized studies are also made with selected food items for use in the school lunch and other food distribution programs for the Department.

The work is conducted at Beltsville, Maryland, and through contract and cooperative agreement at private laboratories and at universities. Food specialists, chemists, bacteriologists, histologists, and statisticians cooperate in this program.

The Federal scientific effort devoted to research in this area totals 10.9 scientific man-years distributed as follows: Horticultural crops 4.9; animal products 2.4; oilseeds and peanuts 1.1; cereals 1.1; guides for consumers 1.9.

PROGRAM OF STATE EXPERIMENT STATIONS

A total of 36.8 scientific man-years is devoted to this area of research.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Horticultural Crops

1. Effect of herbicides on fruit quality. A series of studies are being conducted in cooperation with the Crops Research Division on the effects of herbicide soil treatments on fruits and vegetables. The following investigations involve fruits:

Blueberries and peaches were grown on soil treated with diuron and simazine. Number and rate of applications were plot variables. Blueberries and peaches were evaluated for color, texture, and flavor by panel. Total solids, total and reducing sugars, sucrose, glucose, and fructose also were determined. Physical measurements of color and shear force were made on peaches but not blueberries. A manuscript including the data on total solids and sugar content is in preparation.

Red Rome apples were grown in New Jersey in orchards treated with diuron, simazine, CIPC (isopropyl N (chlorophenyl)carbamate) or emitrole and compared with a plastic mulch treatment, a weedy control, and a clean control. Panel evaluations for flavor and texture were made; shear force values were also obtained. Total solids, total and reducing sugars, sucrose, glucose, fructose, and trace mineral elements are being determined. Relationships between eating quality and composition will be established. A manuscript, including the data on total solids and sugar content is in preparation (see 3-A-2).

2. Effect of insecticide and fungicide treatments on fruit quality. Investigations have been completed on the effect of the insecticides demeton and chlordane, and the herbicides captan and ferbam on palatability and composition of strawberries (see 1966 report 4-A-1, p. 32). These treatments had no detectable effect on color, texture, or flavor of strawberries. Head space analysis of strawberry volatiles from control and treated berries gave similar chromatographic patterns. There were highly significant decreases in the malic acid content of Earlidawn and Armore strawberries treated with demeton. The chlordane-treated fruit showed significant malic acid decreases only for the Earlidawn variety. Decreases in malic acid, titratable acidity, and soluble solids, although statistically significant, were too small to be of practical significance. Residue analysis showed that traces of demeton (less than 0.05 ppm) were found on two of seven demeton-treated samples. Chlordane was found in four out of seven samples of both control berries and chlordane-treated berries. Because all strawberries were grown on soil that had been treated with chlordane the year prior to these experiments, chlordane carry over in the soil could account for the chlordane residues found in the control berries. The data have been analyzed and a manuscript is being prepared.

3. Color of fruits and vegetables. A program has been initiated to determine the qualitative and quantitative changes that take place, after harvest, in the pigments of fruits and vegetables. Preliminary studies on blueberries and sour cherries are under way. This kind of information will serve as a guide to the establishment of household and institutional food storage and food preparation conditions for the maintenance of color quality.

4. Effect of herbicides on vegetable quality. The effects of monuron, amiben, diphenamid, simazine, or linuron treatments on the palatability of asparagus is being studied in cooperation with the Crops Research Division. Panel evaluations of color, flavor, and texture and physical measurements of shear force and color are being made. Trace mineral elements are being determined. This work is in progress.

5. Effect of fumigants and fungicides on vegetable quality. Studies were continued on the effect of PCNB (pentachloronitrobenzene) soil treatment on the palatability and composition of potatoes. Off-flavor due to PCNB treatment could be detected by only one of the six judges. This judge consistently identified potatoes grown in PCNB-treated soil and apparently was extremely sensitive to PCNB. Significant chemical changes were observed. Potatoes grown in PCNB-treated soils were lower in tyrosine content than control potatoes. As a result of the lower tyrosine content, enzymic browning was less in potatoes grown in treated soils than in the control potatoes. There were significant changes in organic acids and amino acids during storage. Changes were greater at 70° F. than at 55° F. Citric acid, alanine, isoleucine, phenylalanine, tyrosine, and valine increased. Aspartic and glutamic acids decreased. A manuscript is being prepared, and a paper describing this research will be presented at the American Chemical Society meeting in Chicago, Illinois, September 10-15, 1967.

Under a contract with the University of California at Los Angeles, research on the effect of soil fumigants and fungicides on fruit and vegetable quality has been initiated. A root crop, carrot; a legume, lima bean; a raw salad vegetable, celery; and a fruit, orange, are to be used in the soil fumigation studies. Fungicides will be used on oranges, strawberries, and tomatoes. The choice of fumigants and fungicides is based upon accepted commercial practices.

Each fruit and vegetable will be examined fresh and after appropriate home preparation including freezing, cooking, canning, and making jelly. The foods are to be analyzed for selected nutrients, including carbohydrates, nitrogenous substances, vitamins, and minerals, as well as for flavor, color, and texture.

6. Insecticide removal from vegetables. Research on the effect of preparation and cooking on the pesticide residues of selected vegetables continued under contract with the National Cannery Association at Washington, D. C., and Berkeley, California.

Malathion residues -- tomatoes. Commercial washing operations removed between 83 and 95 percent of the residue. Commercial processing and juicing of peeled tomatoes lowered the residue to less than 1 percent of the initial value. During home preparation, a cold water wash was ineffective in removing residual malathion; peeling removed more than 90 percent. Storage of fresh tomatoes for 10 days resulted in a decrease of about 30 percent in the malathion residues.

Parathion residues -- spinach. Commercial washing procedures removed only 25 percent of the residue; further processing removed another 40 percent of the initial residue. During home preparation, a cold water wash removed about 39 percent of the initial residue; household blanching and cooking were ineffective in removing parathion. Storage for 12 days at refrigerator temperatures produced no change in residue levels.

DDT residues -- potatoes. Commercial washing removed about 25 percent of the DDT. Washing plus lye-peeling removed about 85 percent. Commercial processing reduced the residue to insignificant level. During home preparation procedures, peeling removed approximately 95 percent of the DDT. Potatoes boiled and pressure cooked without peeling showed no significant decrease in residue level. Residue levels were unchanged in potatoes stored at 45° F. for 6 weeks.

DDT residues -- spinach. Commercial washing operations removed up to 70 percent of the residue depending on the length of the wash; further processing removed approximately 90 percent of the initial DDT residue. During home preparative procedures, washing removed about 30 percent of the DDT residue. After washing, no significant decrease in residue was noted by home cooking; blanching for freezing removed about 53 percent of the initial DDT residue. There was no significant loss of residue during storage at refrigerator temperatures for 15 days.

Carbaryl residues -- spinach. Almost 90 percent of the residue was removed by commercial washing procedures; further processing removed 99 percent of the initial residue. More than 80 percent of the carbaryl residue was removed by home preparative procedures.

Manuscripts have been prepared for publication and phases of this research were presented at the American Chemical Society meetings in New York, September 1966, and Miami Beach, Florida, April 1967. Two papers will be presented at the American Chemical Society meeting in Chicago, Illinois, September 1967.

7. Texture of vegetables. Plans have been developed to initiate research on the textural changes that take place during household and institutional storage of selected vegetables. Histological techniques applied to thin tissue slices will play an important role in these studies. Methodology for cryoscopic microtomy of peas has been developed.

B. Animal Products

1. Cooking conditions, color and tenderness of beef steaks. Statistical analyses of data showed that the effect of broiling treatment upon color and tenderness of 1-1/2 inch steaks varied among the seven beef muscles tested. For instance, soluble pigment content of the Longissimus dorsi muscle in rib steaks decreased significantly with an increase in broiling time when broiled at 350° F., but not when broiled at 250 or 450° F. On the other hand, the soluble pigment contents were similar for chuck steaks (Triceps brachii or Serratus Muscles) broiled at 250, 350, or 450° F. for 15, 20, or 25 minutes. Under comparable broiling conditions, chuck steaks were about as tender as rib and loin steaks, and round steaks (top, bottom, and eye of round) were much less tender than either. With an increase of 100° F. in broiling temperature or 5 minutes in time, steaks from bottom round increased in tenderness, whereas those from the rib and loin became less tender. Steaks were scored medium when broiled to an internal temperature of 140° F. This final internal temperature is usually associated with a rare degree of doneness in rib roasts and illustrates the difficulty of applying results of research on meat prepared by one method of cooking to all other cooking methods. Manuscripts presenting these data are being prepared.

2. Cooking frozen turkeys. Changes in the eating quality characteristics of Beltsville Small White turkeys stored up to 10 months at -5° F. appeared to relate to different roasting times required to reach the internal end-point temperature. The frozen-stored turkeys, after being thawed to room temperature, required a longer cooking time than fresh-unfrozen turkeys to reach a given end-point temperature. This longer cooking time for the frozen-thawed turkeys resulted in higher moisture losses and produced more tender, mealy meat in the frozen-stored as compared to the fresh-unfrozen turkeys. The data suggested that eating quality of fresh and frozen-thawed turkeys would be more alike when turkeys are cooked for equal periods of time rather than to the same internal temperature. If fresh and frozen-thawed turkeys are cooked for equal times, the internal temperature to indicate optimum cooking for frozen-thawed turkeys would be about 10 degrees lower than that recommended for fresh turkeys.

Quantitative changes in raw muscle proteins of the fresh and frozen-stored turkeys as separated from extracts make with KCl-Borate buffer or with de-ionized water were not marked. A decrease in actomyosin nitrogen of

pectoralis major muscle was noted as well as an indication that some proteolytic changes had taken place during storage. It does not appear that the marked changes in eating quality characteristics of stored, frozen turkey stem from these changes in the muscle proteins. Other biochemical systems that may be responsible for these palatability changes will be investigated. A manuscript describing this research is being prepared.

3. Effect of cooking pork on pesticide residues. The study of the effect of cooking on pesticide residues in pork has been continued. Pork shoulder cuts and loin cuts have been cooked and malathion, DDT, and heptachlor analyses are being made by the Entomology Research Division. Loin cuts were cooked for compositional analyses (see 3-B-1). This research is being done in cooperation with the Animal Husbandry and Entomology Research Divisions.

4. Meat safety. Studies have been initiated on the protection of food supplies from harmful microorganisms. Disruption of metabolic pathways in bacteria can inhibit both their growth and their toxin production in meat and meat products prone to spoilage. Procedures designed to disrupt glycolytic activity and fatty acid synthesis in Staphylococcus aureus are being developed. A manuscript is being prepared describing experiments with biotin and chloroquine that resulted in altered lipid synthesis and glycolytic activity in S. aureus.

C. Oilseeds and Peanuts

Research in cooperation with the Agency for International Development, State Department, and other ARS Divisions, was continued on improving the eating quality of foods supplemented with cottonseed, peanut, and soy flours. These foods of plant origin are designed to meet the protein needs of the peoples of developing countries.

Full-fat soy flour samples prepared by the extruder process and a simple process developed for village use were investigated to determine the functional properties and quality when tested in a beverage and baking powder biscuits. Soy flour from the extruder process produced the most satisfactory beverage; soy flour from the village process had poor dispersing properties. There was little difference between samples when soy flour replaced 8 percent of the wheat flour in baking powder biscuits.

Seven experimental flours made from glanded or glandless cottonseed were received from the Southern Utilization Research and Development Division. Gossypol had been removed from the glanded cottonseed by either acetone or hexane extraction. Beverages, biscuits, and breads containing 1 to 10 percent cottonseed flour, based on the weight of finished product, were evaluated by a panel for appearance, aroma, texture, color, flavor, and general acceptability. Products containing acetone extracted, glanded

cottonseed flour were generally poor in color and flavor. Better results were obtained with hexane-extracted cottonseed flour. Improved processing techniques are necessary to improve the characteristics of these cottonseed flours. Glandless cottonseed flours produce products of acceptable flavor. Glandless cottonseed is not a commercially available commodity at this time but shows potential for future international use.

Food formulas that include peanut or soy flour as a major ingredient and developed at Beltsville were further tested under a cooperative agreement with Howard University at Washington, D. C. The formulas were tested for ease of preparation and acceptance by students from developing countries. These formulas will serve as guidelines for household and institutional use of plant proteins in developing countries and should be helpful to extension and Peace Corps workers, nutritionists, and staff in child feeding centers in these countries. Two publications of basic formulas for soups, breads, main dishes, beverages, desserts, and cereal products, such as porridges using peanut and soy flour, have been completed. Twenty-five peanut and 28 soy formulas are in family-size portions. Community-size (50 portions) formulas include 28 peanut and 31 soy formulas. Instructions for preparing 50-portion amounts specified the yield, portion size, grams of protein, and the number of calories per portion. The formulas also are shown in the metric system.

D. Grain and Grain Products

1. Lysine fortified wheat flour. To determine the palatability of wheat fortified with lysine and destined for shipment to India, granular whole-wheat (attas) containing 0.1 to 0.6 percent L-lysine monohydrochloride were prepared at the Western Utilization Research and Development Division. Attas of a higher extraction (93 percent) were made into chapatis (a form of bread native to India) and attas of a lower extraction (85 percent) were made into yeast bread. Sensory quality evaluations of both types of bread were conducted to determine effects of lysine fortification on color, texture, and flavor of chapatis and on flavor of yeast bread. The panel members, in those instances where they thought they detected a difference in flavor between untreated and treated samples preferred the flavor of the lysine chapatis from 63 to 79 percent of the time. A manuscript describing this work is in preparation.

2. Fumigation of wheat. Research was continued on the effects of fumigation of wheat to prevent insect infestation during storage upon the baking performance of flour for home and institutional use. After two years' storage of the wheat, both treated and untreated samples required longer dough fermentation times. Amylograph measurements of flour suspensions showed the phosphine-treated samples to be highest in viscosity and the methyl-bromide fumigated samples lowest of those from

wheats stored at ambient temperatures. Changes in gelatinization temperatures of the starch, measurements of enzyme activity in the grain, and analyses of phosphates will be made on selected samples to explain some of the differences due to fumigation. Amino acid analyses of wheat and flour samples are being made to determine if any amino acids have been methylated by methyl bromide. This research is still underway.

3. Home and commercial bread formulas compared. During the first 12 month's storage of the wheat fumigation study (see 4-D-2), flours milled from the non-fumigated wheats were used to make both home-type and commercial-type breads. Breads made from home-type formulas using ingredients available to homes and institutions had better grain texture and were more tender than breads made with commercial-type formulas and with commercial-type ingredients. Commercial-type breads, however, were higher in loaf volume. This was the first known study in which the same flour was evaluated in both home and commercial use situations. The results indicated that either method may be used to evaluate the quality of wheat flour. A paper "Assessing Wheat Quality with Home- and Commercial-Type Breads" was presented at the American Association of Cereal Chemists meeting in Los Angeles, California, April 1967. A manuscript has been prepared for publication.

4. Cereal-based products. Research was initiated on quality evaluations of a variety of cereal-based foods intended for purchase in the Food for Peace Program. These foods were combinations of two or more of the following: wheat, wheat blends, oats, corn, soy, and millet. Some blends were for use as beverages and porridges while others were intended for making batter-type rolls and Asiatic-type breads such as chapatis, arabis, and shamsi. Physical measurements of the product quality included gel strength, viscosity of hot and cold pastes, gelatinization temperature, dough strength, density, settling of the dry mixture, and stability of the cooked suspensions. A taste panel of five staff members evaluated quality characteristics such as appearance, aroma, texture, and flavor of each experimental sample compared with a reference sample. Results of these evaluations are considered in the Department in making recommendations for the purchase of foods for the Food for Peace Program.

E. Guides for Consumer Programs

1. Food in family meals. Four new consumer publications in press or recently published are "Beef and Veal in Family Meals", "Fruits in Family Meals", "Lamb in Family Meals", and "Milk in Family Meals". A major revision of "Family Fare, Food Management and Recipes" also is in press. These bulletins will help consumers make wise use of food available to them in different market forms. Since "Family Fare", Home and Garden Bulletin No. 1, was originally published in 1950, over a half million copies have been distributed annually to consumers.

A special bulletin on baking, for persons with allergies, contains a variety of recipes for baked products made without wheat, eggs, or milk.

A number of other consumer publications were revised to bring them up to date with the latest research findings and developments in food technology.

In addition to printed publications, a number of radio and television programs were prepared for the networks.

2. Food for low-income families. Recipes developed for raisins, peanut butter, and rolled oats were prepared for distribution to low-income families participating in the USDA food distribution program or the Food Stamp Program. These will supplement the series of 17 leaflets on a variety of commodities originally prepared for a pilot project in Mississippi, for families receiving USDA donated foods, and now available for national distribution as part of the Department's participation in the Federal program to combat poverty. This work, done in cooperation with the Consumer and Marketing Service, will be continued to expand the leaflets and to make field studies of the acceptability of the recipes and food use information developed especially for low-income families. Negotiations were completed with the University of Maryland to have USDA recipes tried by low-income families living in housing developments in Washington, D. C. Participants will fill out a questionnaire reporting the family evaluation of these recipes.

3. Project Head Start--Food buying guide and recipes. A 130-page manual prepared for the Head Start Program of the Office of Economic Opportunity gives quantity recipes and food buying guides needed to prepare nutritionally adequate meals for groups of 25, 50, or more preschool children from low-income families.

Food served in Head Start Centers must be inexpensive to buy, easy to prepare with limited kitchen equipment, and also attractive and appealing to small children who previously may not have had an adequate diet.

4. National School Lunch Program. Research on large quantity food preparation and food quality has provided help to school lunch managers across the nation to make the best use of donated food commodities available to them and other foods obtained on the local market. "Favorite" recipes from schools were standardized and published for other schools to try. A survey of pupil acceptance of these recipes in about 100 schools in five areas of the United States is in progress. Food uses for raisins and peanut butter were developed to help schools use the large quantities distributed to them. Simplified procedures in quantity food production were developed for other nutritious foods that appeal to children and teenagers participating in the National School Lunch Program.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Horticultural Crops

Farrow, R. P., Elkins, E. R., Jr., and Cook, R. W. 1966. Conversion of DDT to TDE in canned spinach. *Four. of Agr. and Food Chem.*, 14: 430-434.

Simandle, P. A., Brogdon, J. L., Sweeney, J. P., Mobley, E. O., and Davis, D. W. 1966. Quality of six tomato varieties as affected by some compositional factors. *Proc. Am. Hort. Soc.*, 89: 532-538.

Dawson, E. H. 1967. Sensory evaluations of foods and beverages. *Food Qual. Control Jour.*, 15: 3-6.

Fulton, L. H., Gilpin, G. L., and Dawson, E. H. 1967. Quality of reconstituted sweetpotato flakes as related to the proportion of water. *Jour. Home Econ.*, 59(2): 124-126.

Animal Products

Woodburn, Margy, and Kim, Chung H. 1966. Survival of Clostridium perfringens during baking and holding of turkey stuffing. *Applied Microb.*, 14(6): 914-92.

Batcher, O. M., Murphy, E. W., Dawson, E. H., Marsh, A. C., Hagan, S. N., and Deary, P. A. 1967. Compositional and palatability characteristics of mild-cured hams in relation to heating, cover fat, and marbling. *Food Tech.*, 21(3A): 474-477.

Bramblett, V. D., and Fugate, K. W. 1967. Choice of cooking temperature for stuffed turkeys. Part I. *J. Home Econ.*, 59: 180.

Hoke, I. M., McGeary, B. K., and Kleve, M. K. 1967. Effect of selected internal and oven temperatures on eating quality of roasted or braised light and dark meat turkey roasts. *J. Food Tech.*, 21: 773.

Woodburn, M., and Ellington, A. E. 1967. Choice of cooking temperature for stuffed turkeys. Part II. *J. Home Econ.* 59: 186.

Guides for Consumers

1966. Storing Perishable Foods in the Home. *Home and Garden Bulletin* No. 78, 12 pp. (Rev.).

1966. Poultry in Family Meals: A Guide for Consumers. *Home and Garden Bulletin* No. 110, 30 pp. (Rev.).

1966. Bread, Cake, and Pastry Recipes for Persons With Allergies to Wheat, Milk, or Eggs. Correspondence Aid 61-17, 9 pp.
1966. How to Make Jellies, Jams, and Preserves at Home. Home and Garden Bulletin No. 56, 30 pp. (Rev.).
1966. Home Freezing of Poultry. Home and Garden Bulletin No. 70, 24 pp. (Rev.).
1966. Protecting Food in the Home. Yearbook of Agriculture, pp. 170-178.
1966. Raisins for Family Meals and Snacks. Fact Sheet. Consumer and Marketing Service, 4 pp.
1966. Peanut Butter for Family Meals. Fact Sheet. Consumer and Marketing Service, 2 pp.
1966. Rolled Oats for Family Meals. Fact Sheet. Consumer and Marketing Service, 4 pp.
1966. Food for Thrifty Families. 17 Flyers. Consumer and Marketing Service, 34 pp.
1967. Beef and Veal in Family Meals: A Guide for Consumers. Home and Garden Bulletin No. 118, 30 pp.
1967. Favorite Quantity Recipes for Type A School Lunches. U. S. Department of Agriculture, 20 pp.

Flavor

- Hornstein, I., and Teranishi, R. 1967. The chemistry of flavor. Chem. and Eng. News, April 3.

Line Project Check List -- Reporting Year July 1, 1966 to June 30, 1967

Work and Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Line Project Summary of Progress (Yes-No)	Incl. in Area and Subheading
HN 1	Nutrients and related substances in foods.			
HN 1-20	Assay and methodological studies of sugars and the application of these methods to the analysis of selected fruits and vegetables. **	Beltsville, Md.	No	
HN 1-22	Effects of fumigation of stored wheat on vitamin content of grain, milling fractions, and home-baked products; and baking performance of flour for household use.	Beltsville, Md.	Yes	3-C-2; 4-D-2
HN 1-23C	Nutrient composition of eggs and quality of the meat from hens treated with malathion.	Maspeth, N.Y.	No	
HN 1-24C	Nutrients of peanuts as affected by lindane treatment of soil.	College Station, Texas	No	
HN 1-25C	Nutrient content of wheat and wheat products: amino acids, B-vitamins, and macro mineral elements.	Chicago, Ill.	Yes	3-C-1
HN 1-26C	Nutrient content of wheat and wheat products: fatty acids.	Lafayette, Ind.	Yes	3-C-1
HN 1-27	Nutrient content of wheat and wheat products: carbohydrate, trace mineral elements, tocopherols, and vitamin B6.	Beltsville, Md.	Yes	3-C-1
HN 1-28C	Fatty acids of fat and lean portions of uncooked and cooked beef and pork.	Madison, Wis.		
HN 1-29	Comparative studies on hydrolytic and analytical procedures for the determination of amino acids in foods.	Columbia, Mo.	Yes	3-B-1
HN 1-30	Isolation and identification of compounds of methionine and threonine with other constituents, formed during heating of foods.	Beltsville, Md.	Yes	3-C-3
HN 1-31	Relationships among nutrients of cheeses and selected dairy products. *	Beltsville, Md.	Yes	3-D-1,2
HN 2	Functions of nutrients and their metabolic interrelationships.			
HN 2-15	Analysis of records of a rat stock colony and development of animals for specific experimental purposes.	Beltsville, Md.	Yes	1-A-4
HN 2-36	The influence of diet on the sequence of histological changes in two strains of rats.	Beltsville, Md.	No	
HN 2-37	The influence of age and diet on enzyme systems in selected tissues of two strains of rats.	Beltsville, Md.	No	
HN 2-39	Exploratory investigations on the effect of diet on body composition of the rat, as determined in vivo or by carcass analyses. **	Beltsville, Md.	No	
HN 2-40	The influence of diet on the lipid metabolism of two strains of rats at various stages in their life cycle.	Beltsville, Md.		

* Initiated during reporting year.

** Discontinued during reporting year.

Line Project Check List -- Reporting Year July 1, 1966 to June 30, 1967

Work and Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Line Project Summary of Progress (Yes-No)	Incl. in Area and Subheading
HN 2-41	:The metabolic response of the rat to : diets containing high levels of : bromide residues.	: : : : Beltsville, Md.	: : : : No	: : : : :
HN 2-42	:Utilization of amino acid and amide : nitrogen of wheat in tissue protein : maintenance.	: : : : Beltsville, Md.	: : : : No	: : : : :
HN 2-43C ^{1/}	:The physiological response of rats to : diets which include different kinds of : fats with and without added chlorinated : hydrocarbon pesticides.	: : : : : : Chicago, Ill.	: : : : : : Yes	: : : : : : 1-A-2
HN 2-44	:The metabolic effects of pesticide : residues in body fat when the content : and distribution of body fat of rats fed : different diets are altered by dietary : restriction.	: : : : : : : : Beltsville, Md.	: : : : : : : : No	: : : : : : : : :
HN 2-45	:Nutritional effects of benzenehexachloride : in microorganisms.	: : : : Beltsville, Md.	: : : : No	: : : : :
HN 2-46	:Metabolic relationships between carbo- : hydrate and nitrogen.	: : : : Beltsville, Md.	: : : : Yes	: : : : 1-C-2
HN 2-47	:The manganese and iron nutrition of : <i>Serratia marcescens</i> in relation to the : effects of these elements on pigment and : hematinenzyme metabolism. **	: : : : : : Beltsville, Md.	: : : : : : No	: : : : : : :
HN 2-49C	:Nutritional response to diets containing : selected types of fresh and oxidized : fats.	: : : : New York, N. Y. : Chicago, Ill.	: : : : : : Yes	: : : : : : 1-A-1
HN 2-50	:The influence of varying dietary com- : position on body composition and : metabolic processes in relation to : physical activity.	: : : : : : College Park & : Beltsville, Md.	: : : : : : : : Yes	: : : : : : : : 1-A-3
HN 2-52C	:The influence of source of dietary carbo- : hydrate fed at different stages of : development on individual variation in : physiological and biochemical response.	: : : : : : Falls Church, Va.	: : : : : : Yes	: : : : : : 1-C-1
HN 2-53GR	:Basic studies of the biochemical response : of the female and offspring to diets con- : taining multipesticide components when : selected minerals are fed at marginal, : excessive, or deficient levels.	: : : : : : : : Gainesville, : Fla.	: : : : : : : : No	: : : : : : : : :
HN 2-54C	:Physiological response to diets con- : taining multipesticide components when : selected minerals are fed at marginal, : excessive or deficient levels.	: : : : : : : : Lafayette, Ind.	: : : : : : : : No	: : : : : : : : :
HN 2-55GR	:Relationship of immunoproteins to protein : status and amino acid intake.	: : : : Ames, Iowa	: : : : Yes	: : : : 1-B-1
HN 2-56GR	:Influence of excessive intakes of certain : vitamins by the mother on pre- and post- : natal development of the young. *	: : : : Cambridge, : Mass.	: : : : : : Yes	: : : : : : 1-E
HN 2-57GR	:Changes in dynamics of calcium metabolism : with age and levels of calcium intake. *	: : : : Louisville, Ky.	: : : : Yes	: : : : 1-D
HN 2-58GR	:Dietary protein level vs. body composition, : aging processes, longevity, and : heredity. *	: : : : : : Stow, Mass.	: : : : : : Yes	: : : : : : 1-B-2

* Initiated during reporting year.

** Discontinued during reporting year.

^{1/} Supported in part by funds from SURD.

Line Project Check List -- Reporting Year July 1, 1966 to June 30, 1967

Work and Line Project Number	Work and Line Project Titles	Work Locations During Past Year:	Line Project Incl. in	
			Summary of Progress (Yes-No)	Area and Subheading
HN 3	:Food quality, preparation, and : preservation.	:	:	:
HN 0-0-1 ^{1/} (AID)	:Household and institutional food uses for : cottonseed, peanut, and soy products in : underdeveloped countries.	:Beltsville, Md. : :Washington, D.C.:	: : Yes	: : 4-C
HN 3-22	:Investigations of the constituents in : cells and cell walls of fruits as : related to eating qualities. **	: :Beltsville, Md.:	: : No	: :
HN 3-24	:Changes in color and tenderness of beef : as influenced by different rates and : extents of heating by broiling. **	:Beltsville, Md. : :Raleigh, N. C.:	: : Yes	: : 4-B-1
HN 3-26 ^{2/}	:Laboratory investigations of food use : problems in the National School Lunch : Program.	: :Beltsville, Md.:	: : Yes	: : 4-E-4
HN 3-27C	:Effect of preparation and cooking on the : pesticide residue content of selected : vegetables.	:Beltsville, Md. : :Washington, D.C.:	: : Yes	: : 4-A-6
HN 3-28 ^{2/}	:Development of new and improved house- : hold procedures for food preparation : as needed to maintain up-to-date : recommendations for consumers.	: :Beltsville, Md.:	: : Yes	: : 4-A-3,7; D-1,4; : 4-E-1,2,3
HN 3-29	:Quality characteristics and nutrient : composition of foods and food products : treated with pesticides and other : agricultural chemicals in food : production.	: :Beltsville, Md.:	: : Yes	: : 3-A-1; : 4-A-1,4
HN 3-30	:Effects of the application of pesticide : chemicals during production on the : palatability, composition, and related : biochemical properties of strawberries.	: :Beltsville, Md.:	: : Yes	: : 4-A-2
HN 3-31	:Palatability and related compositional : changes during home storage of potatoes : grown with PCNB fungicide treatment.	: :Beltsville, Md.:	: : Yes	: : 4-A-5
HN 3-32	:Influence of changes in properties of : muscle proteins of frozen, stored turkey : meat on eating qualities of juiciness, : tenderness, and flavor of cooked meat.	: :Beltsville, Md.:	: : Yes	: : 4-B-2
HN 3-33C	:Effect of fumigants and fungicides on : fruit and vegetable quality. *	:Beltsville, Md. : :Los Angeles, Cal.:	: : Yes	: : 4-A-5
HN 6	:Human nutritional requirements.	:	:	:
HN 6-8C	:Metabolic response of normal adolescent : boys and girls to a standardized diet to : give information on nutritional : requirements.	: :Berrien Springs, : Mich.:	: : Yes	: : 2-A-2
HN 6-9	:Human metabolic response to rate of food : intake. **	: :Beltsville, Md.:	: : No	: :
HN 6-10C	:Determination of nutritional value of : wheat proteins for adult man.	:East Lansing, : Mich.:	: : Yes	: : 2-B-1
HN 6-11C	:Nutritional value of wheat flour for adult : man when fed alone and in combination : with legumes or other cereals.	: :Greensboro, N.C.:	: : Yes	: : 2-B-1
:	:	:	:	:

* Initiated during reporting year.

** Discontinued during reporting year.

1/ Supported in part by funds from Agency for International Development, State Department.

2/ Supported in part by funds from Consumer and Marketing Service.

* Initiated during reporting year.

1/ In cooperation with Consumer and Food Economics Research Division, ARS, and University of Hawaii.

* Initiated during reporting year.

